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Research Report

A LONGITUDINAL STUDY OF HEALTHY YOUNG MEN:

CORRELATION COEFFICIENTS

Robert K. Osborne, William R. Harlan, Jr., and Ashton Graybiel

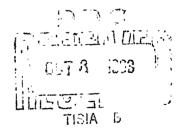
Bureau of Medicine and Surgery Project MR005.13–3001 Subtask 2 Report No.7

119073

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U. S. NAVAL SCHOOL OF AVIATION MEDICINE
U. S. NAVAL AVIATION MEDICAL CENTER
PENSACOLA, FLORIDA

SUMMARY PAGE

THE PROBLEM

A large body of data has been accumulated in a continuing epidemiological study of naval aviators. It was necessary to explore methods which would allow expression of important relationships which could be investigated further. An IBM 1620 computer has been used to construct a large matrix of correlation coefficients for this purpose.

FINDINGS

The relationships among data from three examinations conducted over a period of eighteen years on a group of healthy young men are presented in the form of correlation coefficients. A correlation matrix of 106 continuous variables is recorded as a reference for other investigators. Pertinent statistical considerations are outlined and briefly discussed.

ACKNOWLEDGMENTS

The authors gratefully acknowledge the assistance of Mr. Roger Berkshire, Mrs. Margaret Duty, and LT Robert Wherry, MSC, USN, without whose help compilation of the matrix would not have been possible. Special thanks are extended to Mrs. Joyce Gill who so capably typed the many thousands of numbers in the matrix.

INTRODUCTION

A large number of epidemiologic studies are in progress oriented toward identification of factors important in the development of hypertension and arteriosclerotic disease. The majority of these studies are concerned with populations selected in middle age, and there is little information available on young adults. During the period prior to middle age, important patterns develop which influence and foreshadow the future development of vascular disease. Changes occur in various physiologic parameters and cannot be appreciated from studies of older populations. We have completed an eighteen-year follow-up in a longitudinal study of healthy young men first evaluated at 24 years of age. Follow-up examination was conducted on 96 per cent of the surviving members. The availability of a large body of unique data prompted us to investigate the relationships among the various parameters studied.

The purpose of this communication is to present the data from this study in the form of a correlation matrix of the relationships among 106 continuous variables. This matrix is presented as a source of reference for those engaged in this type of study and perhaps as a point of departure for those who find interesting relationships. Important aspects of blood pressure, electrocardiograms, and serum lipids have been presented elsewhere, and no comment will be offered on the individual correlation coefficients.

PROCEDURE

Several publications give detailed summaries of the selection, testing, and subsequent follow-up evaluations of this group (1-5). The study group is composed of 1056 healthy white males selected as physically qualified for flight training in 1940. The original studies were performed in 1940 when the mean age of the group was 23.6 years. Included in the original evaluation were height, weight, blood pressure (casual and basal), basal metabolic rate, electrocardiogram (3 standard leads plus Cf 4), somatotyping from profile nude photographs as described by Sheldon (6), Minnesota paper formboard scores, and Otis mental aptitude test scores.

In 1952, the group was re-evaluated with 88 per cent of the surviving members being examined. A history, physical examination, chest x-ray, and an electrocardiogram (12-lead) were included in this examination.

In 1958, all but three members of the original group were located, and 785 (96 per cent) of the surviving members were examined. All deaths were documented. Evaluation in 1958 included a detailed history and physical examination and the following laboratory studies: electrocardiogram (12 lead with "double" Master two-step test*), serum

^{*}Using standard Master steps and the table of trips (7), the subject makes double the regulation number of trips in double the usual period of time.

cholesterol and serum lipoprotein analyses. The electrocardiograms from all three examinations were measured and interpreted by two physicians independently with the final interpretation being agreed upon by both. Data from these examinations were coded and placed on IBM cards. An IBM 1620 computer was utilized to calculate Pearson Product Moment Correlations coefficients according to the formula

where \underline{x} and \underline{y} are the variables and \underline{n} the number of paired observations.

Preliminary plotting of correlations between randomly selected variables indicated the relationships examined were linear.

RESULTS

The correlation coefficients are presented in the usual matrix form. The correlation coefficient is the upper number, and the lower figure is the number of observations from which the correlation is derived. A list of the variables with the mean and standard deviation of each is listed below:

GENERAL DATA

Sys BP 1940	Systolic blood pressure, 1940 (casual, supine)	120.7 (<u>+</u> 8.6) mm Hg
Dias BP 1940	Diastolic blood pressure, 1940 (casual, supine)	71.8 (<u>+</u> 7.7) mm Hg
Sys BP 1952	Systolic blood pressure, 1952 (casual, supine)	123.7 (± 13.4) mm Hg
Dias BP 1952	Diastolic blood pressure, 1952 (casual, supine)	76.1 (<u>+</u> 10.7) mm Hg
Sys BP 1958	Systolic blood pressure, 1958 (casual, supine)	123.0 (<u>+</u> 13.5) mm Hg
Dias BP 1958	Diastolic blood pressure, 1958 (casual, supine)	77.7 (<u>+</u> 9.7) mm Hg
△ Sys 40-52	Change in systolic blood pressure 1940-1952	2.8 (<u>+</u> 14.8) mm Hg
△ Dias 40-52	Change in diastolic blood pressure 1940-1952	4.3 (<u>+</u> 12.2) mm Hg
△ Sys 52-58	Change in systolic blood pressure 1952–1958	-0.96 (<u>+</u> 13.9) mm Hg
△ Dias 52-58	Change in diastolic blood pressure 1952-1958	1.5 <u>(+</u> 11.6) mm Hg
△ Sys 40-58	Change in systolic blood pressure 1940-1958	2.3 (<u>+</u> 14.6) mm Hg
△ Dias 40-58	Change in diastolic blood pressure 1940-1958	6.0 (<u>+</u> 11.4) mm Hg

Age 1940	Age, 1940	23.6 (<u>+</u> 2.3) years
Age 1952	Age, 1952	35.1 (<u>+</u> 2.3) years
Age 1958	Age, 1958	41.2 (<u>+</u> 2.3) years
△ Age 40-52	Change in age, 1940-1952	11.5 (<u>+</u> 1.1) years
△ Age 52-58	Change in age, 1952-1958	6.2 (<u>+</u> 1.1) years
△ Age 40-58	Change in age, 1940-1958	17.7 (<u>+</u> 1.1) years
BMR	Basal metabolic rate	-1.7 <u>(+</u> 9.7)
OMA	Otis Mental Aptitude	35.0 (<u>+</u> 23.7)
MPF	Minnesota Paper Form	30.1 (<u>+</u> 21.0)
R 1940	Mean body radius * , 1940	133.9 (<u>+</u> 7.5)
R 1952	Mean body radius*, 1952	140.1 <u>(+</u> 7.2)
R 1958	Mean body radius*, 1958	141.3 <u>(+</u> 7.1)
△ R 40-52	Change in R, 1940 to 1952	6.05 (<u>+</u> 5.4)
△R 52-5 8	Change in R, 1952 to 1958	1.12 (+ 4.3)
△R 40-58	Change in R, 1940 to 1958	7.20 (<u>+</u> 5.7)
Ht/Wt 1940	Height/weight, 1940	0.443 (± 0.038)in./lbs
Ht/Wt 1952	Height/weight, 1952	0.408 (<u>+</u> 0.042)in./lbs.
Ht/Wt 1958	Height/weight, 1958	0.401 (± 0.039)in./lbs.
△ Ht/wt 40-52	Change in ht/wt, 1940–1952	0.036 (± 0.032)in./lbs.
△Ht/wt 52-58	Change in ht/wt, 1952–1958	0.007 (± 0.025)in./lbs.
ДHt/wt 40-58	Change in ht/wt, 1940-1958	0.043 (<u>+</u> 0.034)in./lbs.
H+_1940	Height, 1940	70.3 (<u>+</u> 2.15) inches

*As described by Behnke (8).

Wt 1940	Weight, 1940	159.8 (<u>+</u> 15.6) lbs.
Wt 1952	Weight, 1952	174.2 (<u>+</u> 19.8) lbs.
Wt 1958	Weight, 1958	177.2 (<u>+</u> 19.8) lbs.
△ Wt 40-52	Change in weight, 1940-1952	14.56 (<u>+</u> 13.2) lbs.
△ Wt 52-58	Change in weight, 1952–1958	2.74 (<u>+</u> 10.4) lbs.
△ Wt 40-58	Change in weight, 1940–1958	17.48 (<u>+</u> 14.2) lbs.
% Dev. 1940	Percent deviation from average weight (Metropolitan tables), 1940	-1.10 (<u>+</u> 8.35)%
% Dev. 1952	Percent deviation from average weight (Metropolitan tables), 1952	+1.41 (+ 10.00)%
% Dev. 1958	Percent deviation from average weight (Metropolitan tables), 1958	+1.37(<u>+</u> 9.72)%
△ %Dev.40-52	2 Change in % deviation from average weight 1940–1952	+2.62 (+ 8.34)%
△ %Dev.52-58	3 Change in % deviation from average weight 1952–1958	-0.14 (<u>+</u> 6.29)%
△ %Dev.40-58	3 Change in % deviation from average weight 1940–1958	+ 2.48 (+ 8.76)%
Endo	Endomorphy (score on each individual's endomorphic components × 2 to eliminate fractions, 1940)	6.31 (<u>+</u> 1.84)
Meso	Mesomorphy (score on each individual's mesomorphic components x 2 to eliminate fractions, 1940)	8.83 (<u>+</u> 1.69)
Ecto	Ectomorphy (score on each individual's ectomorphy components × 2 to eliminate fractions, 1940)	6.26 (<u>+</u> 2.14)
Endo-Meso	Endomorphy plus mesomorphy, 1940 (addition of these two components for each individual)	15.14 (<u>+</u> 2.22)

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Chol.	Cholesterol, Abell method (9) 1958	226.6 (<u>+</u> 45.81)mg%
A.I.	Atherogenic Index (derived from lipoprotein analysis performed at Institute of Medical Physics: AI = 0.1 (Sf 0-12) + 0.175 (Sf 12-400) Sf in mg/100 ml 1958 (10)	84.71 (<u>+</u> 28. <i>7</i> 7)
Sf 12-20	Sf 12-20 Lipoprotein fraction, 1958	41.67 (<u>+</u> 10.67)
Electro	ocardiographic Data	
Rate 1940	Rate, 1940	63.35 (<u>+</u> 10.60)per min.
Rate 1952	Rate, 1952	74.48 (<u>+</u> 11.47)per min.
Rate 1958	Rate, 1958	71.02 (<u>+</u> 10.87)per min.
	Change in rate, 1940–1952	11.20 (<u>+</u> 13.75)per min.
△ Rate 52-58	Change in rate, 1952–1958	3.97 (<u>+</u> 12.00)per min.
△ Rate 40-58	Change in rate, 1940–1958	7.51 (<u>+</u> 12.63)per min.
PR 1940	PR interval, 1940	0.154 (<u>+</u> 0.02) mm
PR 1952	PR interval, 1952	0.160 (<u>+</u> 0.02) mm
PR 1958	PR interval, 1958	0.167 (<u>+</u> 0.04) mm
△ PR 40-52	Change in PR, 1940–1952	0.004 (<u>+</u> 0.02) mm
△ PR 52-58	Change in PR, 1952-1958	0.006 (<u>+</u> 0.02) mm
△ PR 40-58	Change in PR, 1940-1958	0.011 (<u>+</u> 0.02) mm
QRS 1940	QRS duration, 1940	0.088 (<u>+</u> 0.02) mm
QRS 1952	QRS duration, 1952	0.086 (<u>+</u> 0.01) mm
QRS 1958	QRS duration, 1958	0.087 (<u>+</u> 0.01) mm
QT 1940	QT interval, 1940	0.385 (<u>+</u> 0.036) mm
QT 1952	QT interval, 1952	0.360 (<u>+</u> 0.029) mm

QT 1958	QT interval, 1958	0.365 (<u>+</u> 0.033) mm
△ QT 40-52	Change in QT, 1940-1952	0.024 (<u>+</u> 0.040) mm
∠ QT 52-58	Change in QT, 1952-1958	0.006 (<u>+</u> 0.035) mm
△ QT 40-58	Change in QT, 1940-1958	0.017 (<u>+</u> 0.038) mm
QRS Vec. 1940	QRS frontal vector, 1940	60.76 (+ 26.87)°
QRS Vec. 1952	QRS frontal vector, 1952	47.90 (<u>+</u> 29.07)°
QRS Vec. 1958	QRS frontal vector, 1958	41.66 (<u>+</u> 34.52)°
△ QRS Vec.40	0-52 Change QRS frontal vector, 1940-1952	12.81(<u>+</u> 17.37)°
△ QRS Vec.52	2-58 Change QRS frontal vector, 1952-1958	6.59 (<u>+</u> 18.80)°
△ QRS Vec.40	0-58 Change QRS frontal vector, 1940-1958	19.63 (<u>+</u> 24.59)°
Master rate	Maximum rate achieved after double Master two-step test, 1958	86.45 (<u>+</u> 17.45)per min.
Master rate	Increase in rate with double Master two- step test, 1958	16.16 (<u>+</u> 12.68)per min.
T Vec.1940	T frontal vector, 1940	43.08 (<u>+</u> 18.29)°
T Vec. 1952	T frontal vector, 1952	41.13 (<u>+</u> 18.41)°
T Vec. 1958	T frontal vector, 1958	39.13 (<u>+</u> 19.24)°
△ T Vec.40-5	2 Change in T vector, 1940-1952	3.23 (<u>+</u> 18.04)°
<u> </u>	8 Change in T vector, 1952–1958	2.70 (<u>+</u> 16.32)°
△ T Vec.40-5	8 Change in T vector, 1940-1958	4.86 (<u>+</u> 19.03)°
QRS-T 1940	QRS-T angle, frontal, 1940	24.75 (<u>+</u> 18.07)°
QRS-T 1952	QRS-T angle, frontal, 1952	21.84 (<u>+</u> 19.71)°
QRS-T 1958	QRS-T angle, frontal, 1958	23.75 (<u>+</u> 22.18)°

Δ QRS-T 40-52 Change QRS-T angle, 1940-1952	3.22 (<u>+</u> 19.33)°
△ QRS-T 52-58 Change QRS-T angle, 1952-1958	1.59 (+ 18.72)9
△ QRS-T 40-58 Change in QRS-T angle, 1940-1958	2.40 (<u>+</u> 23.04)°
Init, 0.04 1940 Initial 0.04 vector, 1940	46.68 (<u>+</u> 24.32)°
Init, 0.04 1952 Initial 0.04 vector, 1952	39.15 (<u>+</u> 44.52)°
Init, 0.04 1958 Initial 0.04 vector, 1958	33.62 (<u>+</u> 24.80)°
△ Init, 0.04 40-52 Change initial 0.04 vector, 1940-1952	4.42 (<u>+</u> 20.91)°
△ Init, 0.04 52–58 Change initial 0.04 vector, 1952–1958	5.43 (<u>+</u> 16.67)°
△ Init, 0.04 40-58 Change initial 0.04 vector, 1940-1958	9.24 (<u>+</u> 22.16)°
Term. 0.04 1940 Terminal 0.04 vector, 1940	53.26 (<u>+</u> 80.36)°
Term. 0.04 1952 Terminal 0.04 vector, 1952	32.22 (<u>+</u> 85.25)°
Term.0.04 1958 Terminal 0.04 vector, 1958	28.93 (<u>+</u> 81.62)°
△ Term.0.04 40-52 Change terminal 0.04 vector, 1940-1952	6.24 (<u>+</u> 31.72)°
△ Term.0.04 52-58 Change terminal 0.04 vector, 1952-1958	2.20 (<u>+</u> 28.44)°
△ Term.0.04 40-58 Change terminal 0.04 vector, 1940-1958	9.56 (<u>+</u> 39.52)°

DISCUSSION

No attempt will be made to comment on individual correlations or significant relations hips; however, there are several considerations and qualifications to be recognized in interpreting this correlation matrix. From the statistical standpoint, the N, or number of paired observations, is large (usually over 600).

If the N is assumed to be 600, the correlations may be considered significant when exceeding the following values*: .70 at 5 per cent confidence level, .098 at 1 per cent level, and .108 at 0.5 per cent level. It will be recalled that at the 5 per cent confidence level one in twenty correlations will be "significant," though spurious, and

^{*}Determined by extrapolation from a standard table of significance values for correlation coefficients (4).

one in a hundred at the 1 per cent level. The importance of correlation coefficients at levels below .25 in a study of this size is well exemplified by experience with the analysis of factors influencing blood pressure (4). Correlations of .15 to .20 were present in several parameters when data from the entire group were examined. An analysis of variance of these parameters for groups within the study population revealed significant differences (P < .01 to P < .001) which had clinical importance. In a relatively homogeneous group there is a tendency for the large middle group without strong differences to "dilute" significant differences at the ends of distribution of a variable. Therefore, it may be of value to pursue significant, though less striking, correlations through selection of a group designed to emphasize the characteristics under consideration. The reverse proposition is also true. Where no significant correlation is present, a study of similar composition would not be expected to yield significant results.

Another consideration involves the factitial elevation of a correlation coefficient when the one variable is derived in part from its correlate. Several items within the matrix refer to "change" in a parameter between two examinations. The relationship between the "change" parameter and either of the two measurements from which it is derived should theoretically be \pm .71 even if the two measurements were unrelated (if the measurements had the same standard deviation). As a consequence, little importance can be attached to correlations between a variable and a derivative of this variable.

The Pearson product moment equation is designed to express linear relationships only. In spite of the fact that all of the relationships examined prior to use of the computor were linear (based on examination of scatter plots), there is no assurance that all of the underlying relationships among the variables are truly linear. The Pearson equation gives an underestimate of the true relationship between two variables when the true relationship is nonlinear.

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The purpose of this communication is to present the data from this study in the form of a correlation matrix of the relationships among 106 continuous variables. This matrix is presented as a source of reference for those engaged in this type of study and perhaps as a point of departure for those who find interesting relationships. Important aspects of blood pressure, electrocardiograms, and serum lipids have been presented elsewhere, and no comment will be offered on the individual correlation coefficients.

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In 1952, the group was re-evaluated with 88 per cent of the surviving members being examined. A history, physical examination, chest x-ray, and an electrocardiogram (12-lead) were included in this examination.

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^{*}Using standard Master steps and the table of trips (7), the subject makes double the regulation number of trips in double the usual period of time.

cholesterol and serum lipoprotein analyses. The electrocardiograms from all three examinations were measured and interpreted by two physicians independently with the final interpretation being agreed upon by both. Data from these examinations were coded and placed on IBM cards. An IBM 1620 computer was utilized to calculate Pearson Product Moment Correlations coefficients according to the formula

where x and y are the variables and n the number of paired observations.

Preliminary plotting of correlations between randomly selected variables indicated the relationships examined were linear.

RESULTS

The correlation coefficients are presented in the usual matrix form. The correlation coefficient is the upper number, and the lower figure is the number of observations from which the correlation is derived. A list of the variables with the mean and standard deviation of each is listed below:

GENERAL DATA

Systolic blood pressure, 1940 (casual, supine)	1 20.7 (<u>+</u> 8.6) mm Hg
Diastolic blood pressure, 1940 (casual, supine)	71.8 (<u>+</u> 7.7) mm Hg
Systolic blood pressure, 1952 (casual, supine)	123.7 (<u>+</u> 13.4) mm Hg
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Diastolic blood pressure, 1958 (casual, supine)	77.7 (<u>+</u> 9.7) mm Hg
Change in systolic blood pressure 1940-1952	2.8 (<u>+</u> 14.8) mm Hg
Change in diastolic blood pressure 1940-1952	4.3 (<u>+</u> 12.2) mm Hg
Change in systolic blood pressure 1952-1958	-0.96 (<u>+</u> 13.9) mm Hg
Change in diastolic blood pressure 1952-1958	1.5 (<u>+</u> 11.6) mm Hg
Change in systolic blood pressure 1940-1958	2.3 (<u>+</u> 14.6) mm Hg
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Age 1940	Age, 1940	23.6 (<u>+</u> 2.3) years	
Age 1952	Age, 1952	35.1 (<u>+</u> 2.3) years	
Age 1958	Age, 1958	41.2 (± 2.3) years	
△ Age 40-52	Change in age, 1940-1952	11.5 (<u>+</u> 1.1) years	
△ Age 52-58	Change in age, 1952–1958	6.2 (<u>+</u> 1.1) years	
△ Age 40-58	Change in age, 1940-1958	17.7 (<u>+</u> 1.1) years	
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*As described by Behnke (8).			

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△ Wt 40-58	Change in weight, 1940–1958	17.48 (<u>+</u> 14.2) lbs.
% Dev. 1940	Percent deviation from average weight (Metropolitan tables), 1940	-1.10 (<u>+</u> 8.35)%
% Dev. 1952	Percent deviation from average weight (Metropolitan tables), 1952	+1.41 (+ 10.00)%
% Dev. 1958	Percent deviation from average weight (Metropolitan tables), 1958	+1.37 <u>(+</u> 9.72)%
△ %Dev.40-52	P. Change in % deviation from average weight 1940–1952	+2.62 (+ 8.34)%
△ %Dev.52-58	Change in % deviation from average weight 1952–1958	-0.14 (<u>+</u> 6.29)%
△ %Dev.40-58	Change in % deviation from average weight 1940–1958	+ 2.48 (+ 8.76)%
Endo	Endomorphy (score on each individual's endomorphic components x 2 to eliminate fractions, 1940)	6.31 (<u>+</u> 1.84)
Meso	Mesomorphy (score on each individual's mesomorphic components \times 2 to eliminate fractions, 1940)	8.83 (<u>+</u> 1.69)
Ecto	Ectomorphy (score on each individual's ectomorphy components x 2 to eliminate fractions, 1940)	6.26 (<u>+</u> 2.14)
Endo-Meso	Endomorphy plus mesomorphy, 1940 (addition of these two components for each individual)	15.14 (<u>+</u> 2.22)

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Chol.	Cholesterol, Abell method (9) 1958	226.6 (<u>+</u> 45.81)mg%
A.I.	Atherogenic Index (derived from lipoprotein analysis performed at Institute of Medical Physics: AI = 0.1 (Sf 0-12) + 0.175 (Sf 12-400) Sf in mg/100 ml 1958 (10)	84.71 (<u>+</u> 28. <i>7</i> 7)
Sf 12-20	Sf 12–20 Lipoprotein fraction, 1958	41.67 (+ 10.67)
Electro	ocardiographic Data	
Rate 1940	Rate, 1940	63.35 (<u>+</u> 10.60)per min.
Rate 1952	Rate, 1952	74.48 (<u>+</u> 11.47)per min.
Rate 1958	Rate, 1958	71.02 (<u>+</u> 10.87)per min.
△ Rate 40-52	Change in rate, 1940-1952	11.20 (<u>+</u> 13.75)per min.
△ Rate 52-58	Change in rate, 1952–1958	3.97 (<u>+</u> 12.00)per min.
△ Rate 40-58	Change in rate, 1940–1958	7.51 (<u>+</u> 12.63)per min.
PR 1940	PR interval, 1940	0.154 (<u>+</u> 0.02) mm
PR 1952	PR interval, 1952	0.160 (<u>+</u> 0.02) mm
PR 1958	PR interval, 1958	0.167 (<u>+</u> 0.04) mm
△ PR 40-52	Change in PR, 1940-1952	0.004 (<u>+</u> 0.02) mm
△ PR 52-58	Change in PR, 1952-1958	0.006 (<u>+</u> 0.02) mm
△ PR 40-58	Change in PR, 1940-1958	0.011 (<u>+</u> 0.02) mm
QRS 1940	QRS duration, 1940	0.088 (<u>+</u> 0.02) mm
QRS 1952	QRS duration, 1952	0.086 (<u>+</u> 0.01) mm
QRS 1958	QRS duration, 1958	0.087 (<u>+</u> 0.01) mm
QT 1940	QT interval, 1940	0.385 (<u>+</u> 0.036) mm
QT 1952	QT interval, 1952	0.360 (± 0.029) mm

QT 1958	QT interval, 1958	0.365 (<u>+</u> 0.033) mm
△ QT 40-52	Change in QT, 1940-1952	0.024 (<u>+</u> 0.040) mm
∠ QT 52-58	Change in QT, 1952-1958	0.006 (<u>+</u> 0.035) mm
△ QT 40-58	Change in QT, 1940-1958	0.017 (<u>+</u> 0.038) mm
QRS Vec. 1940	QRS frontal vector, 1940	60.76 (<u>+</u> 26.87)°
QRS Vec. 1952	QRS frontal vector, 1952	47.90 (<u>+</u> 29.07)°
QRS Vec. 1958	QRS frontal vector, 1958	41.66 (<u>+</u> 34.52)°
△ QRS Vec.40	9-52 Change QRS frontal vector, 1940-1952	12.81(<u>+</u> 17.37)°
△ QRS Vec.52	2-58 Change QRS frontal vector, 1952-1958	6.59 (<u>+</u> 18.80)°
△ QRS Vec.40	9-58 Change QRS frontal vector, 1940-1958	19.63 (<u>+</u> 24.59)°
Master rate	Maximum rate achieved after double	0/ 45 /: 17 45
	Master two-step test, 1958	86.45 (<u>+</u> 17.45)per min.
Master rate	Increase in rate with double Master two- step test, 1958	16.16 (<u>+</u> 12.68)per min.
Master rate T Vec. 1940	Increase in rate with double Master two-	-
	Increase in rate with double Master two- step test, 1958	16.16 (<u>+</u> 12.68)per min.
T Vec.1940	Increase in rate with double Master two- step test, 1958 T frontal vector, 1940	16.16 (<u>+</u> 12.68)per min. 43.08 (<u>+</u> 18.29) ^o
T Vec. 1940 T Vec. 1952 T Vec. 1958	Increase in rate with double Master two- step test, 1958 T frontal vector, 1940 T frontal vector, 1952	16.16 (<u>+</u> 12.68)per min. 43.08 (<u>+</u> 18.29) ^o 41.13 (<u>+</u> 18.41) ^o
T Vec. 1940 T Vec. 1952 T Vec. 1958 \$\triangle \tau \text{T Vec. 40-52} \text{T}\$	Increase in rate with double Master two- step test, 1958 T frontal vector, 1940 T frontal vector, 1952 T frontal vector, 1958	16.16 (± 12.68)per min. 43.08 (± 18.29)° 41.13 (± 18.41)° 39.13 (± 19.24)°
T Vec. 1940 T Vec. 1952 T Vec. 1958 \$\Delta\$ T Vec. 40-52 \$\Delta\$ T Vec. 52-58	Increase in rate with double Master two-step test, 1958 T frontal vector, 1940 T frontal vector, 1952 T frontal vector, 1958 Change in T vector, 1940–1952	16.16 (± 12.68)per min. 43.08 (± 18.29)° 41.13 (± 18.41)° 39.13 (± 19.24)° 3.23 (± 18.04)°
T Vec. 1940 T Vec. 1952 T Vec. 1958 \$\Delta\$ T Vec. 40-52 \$\Delta\$ T Vec. 52-58	Increase in rate with double Master two-step test, 1958 T frontal vector, 1940 T frontal vector, 1952 T frontal vector, 1958 Change in T vector, 1940–1952 Change in T vector, 1952–1958	16.16 (± 12.68)per min. 43.08 (± 18.29)° 41.13 (± 18.41)° 39.13 (± 19.24)° 3.23 (± 18.04)° 2.70 (± 16.32)°
T Vec. 1940 T Vec. 1952 T Vec. 1958 \$\triangle \tau \tau \text{Vec. 40-52}\$ \$\triangle \tau \text{Vec. 52-58}\$ \$\triangle \tau \text{Vec. 40-58}\$	Increase in rate with double Master two-step test, 1958 T frontal vector, 1940 T frontal vector, 1952 T frontal vector, 1958 Change in T vector, 1940–1952 Change in T vector, 1940–1958 Change in T vector, 1940–1958	16.16 (± 12.68)per min. 43.08 (± 18.29)° 41.13 (± 18.41)° 39.13 (± 19.24)° 3.23 (± 18.04)° 2.70 (± 16.32)° 4.86 (± 19.03)°

△ QRS-T 40-52 Change QRS-T angle, 1940-1952	3.22 (<u>+</u> 19.33)°
△ QRS-T 52-58 Change QRS-T angle, 1952-1958	1.59 (+ 18.72)
△ QRS-T 40-58 Change in QRS-T angle, 1940-1958	2.40 (<u>+</u> 23.04)°
Init, 0.04 1940 Initial 0.04 vector, 1940	46.68 (<u>+</u> 24.32)°
Init, 0.04 1952 Initial 0.04 vector, 1952	39.15 (<u>+</u> 44.52)°
Init, 0.04 1958 Initial 0.04 vector, 1958	33.62 (<u>+</u> 24.80)°
△ Init, 0.04 40-52 Change initial 0.04 vector, 1940-1952	4.42 (+ 20.91)°
△ Init, 0.04 52-58 Change initial 0.04 vector, 1952-1958	5.43 (<u>+</u> 16.67)°
△ Init, 0.04 40-58 Change initial 0.04 vector, 1940-1958	9.24 (<u>+</u> 22.16)°
Term. 0.04 1940 Terminal 0.04 vector, 1940	53.26 (<u>+</u> 80.36)°
Term. 0.04 1952 Terminal 0.04 vector, 1952	32.22 (<u>+</u> 85.25)°
Term.0.04 1958 Terminal 0.04 vector, 1958	28.93 (<u>+</u> 81.62)°
△ Term.0.04 40-52 Change terminal 0.04 vector, 1940-1952	6.24 (<u>+</u> 31.72)°
△ Term.0.04 52-58 Change terminal 0.04 vector, 1952-1958	2.20 (<u>+</u> 28.44)°
△ Term.0.04 40-58 Change terminal 0.04 vector, 1940-1958	9.56 (<u>+</u> 39.52)°

DISCUSSION

No attempt will be made to comment on individual correlations or significant relations hips; however, there are several considerations and qualifications to be recognized in interpreting this correlation matrix. From the statistical standpoint, the \underline{N} , or number of paired observations, is large (usually over 600).

If the N is assumed to be 600, the correlations may be considered significant when exceeding the following values*: .70 at 5 per cent confidence level, .098 at 1 per cent level, and .108 at 0.5 per cent level. It will be recalled that at the 5 per cent confidence level one in twenty correlations will be "significant," though spurious, and

^{*}Determined by extrapolation from a standard table of significance values for correlation coefficients (4).

one in a hundred at the 1 per cent level. The importance of correlation coefficients at levels below .25 in a study of this size is well exemplified by experience with the analysis of factors influencing blood pressure (4). Correlations of .15 to .20 were present in several parameters when data from the entire group were examined. An analysis of variance of these parameters for groups within the study population revealed significant differences (P < .01 to P < .001) which had clinical importance. In a relatively homogeneous group there is a tendency for the large middle group without strong differences to "dilute" significant differences at the ends of distribution of a variable. Therefore, it may be of value to pursue significant, though less striking, correlations through selection of a group designed to emphasize the characteristics under consideration. The reverse proposition is also true. Where no significant correlation is present, a study of similar composition would not be expected to yield significant results.

Another consideration involves the factitial elevation of a correlation coefficient when the one variable is derived in part from its correlate. Several items within the matrix refer to "change" in a parameter between two examinations. The relationship between the "change" parameter and either of the two measurements from which it is derived should theoretically be ± .71 even if the two measurements were unrelated (if the measurements had the same standard deviation). As a consequence, little importance can be attached to correlations between a variable and a derivative of this variable.

The Pearson product moment equation is designed to express linear relationships only. In spite of the fact that all of the relationships examined prior to use of the computor were linear (based on examination of scatter plots), there is no assurance that all of the underlying relationships among the variables are truly linear. The Pearson equation gives an underestimate of the true relationship between two variables when the true relationship is nonlinear.

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567 552 525 .12 .17 651 647 .13 -.06 .07 .15 647 619 622 651 .09 -.03 647 619 .16 622 .19 647 .06 622 .14 378 .09 -.03 371 590 .10 -.03 .08 393 585 624 .12 .11 589 -.01 570 -.08 -.07 -.01 -.02 645 616 619 651 .09 ,15 647 .11 622 -.09 .05 .13 619 622 651 ,20 647 ,13 -,01 ,13 539 388 406 .11 574 .15 .10 -.10 .05 622 647 619 622 .12 .04 -,13 539 539 539 .01 378 .02 -.08 .07 -.10 .17 .03 -.03 -.00 .07 .06 575 617 610 565 591 353 575 617 610 564 -.02 .06 -.06 -.02 633 632 637 640 .03 .01 .08 .07 -.03 -.01 635 635 640 640 635 .02 .05 -.03 .05 .10 -.00 527 527 527 527 407 419 .01 403 .02 .07 -.00 -.01 -.00 -.07 .05 -.06 .09 -.08 591 553 579 617 610 575 615 619 565 592 .03 .02 .06 .06 640 635 636 639 .04 -.00 -.03 -.01 -.07 .05 -.05 353 572 604 592 357 371 538 .08 .01 .01 -.02 397 390 580 616 .02 ,13 -.08 -.05 -.01 -.02 .05 -.02 ,14 .09 .01 -.03 .06 -.04 .14 .07 .04 .03 -.03 .03 632 637 640 640 635 640 635 640 635 640 635 640 635 640 635 640 635 640 635 .08 -.00 .02 -.07 640 638 633 637 .04 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626 575 569
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649 568 643 567 560 641 398 391 658 576 655 576 573 655 649
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622 643 622
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565 648
   0RS vec. 40-52
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   485 vec. 52-58
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643 436 430 645 611 710 562 610 645
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643
    42 S vec. 40 - 51
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355 349 622 622 565 622 565
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622
    A 085 vec. 40-52
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385 380 561 609 608 561
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606
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560
     A 985 vec. 52-56
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387 382 643 560 643 560
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643
     △ 985 vec. 40-56
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448 402 403 447 342 398 397 395
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395 396 440 355 391 390 389 386
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631 657 631 574 657 719 623
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626 631 626 574 622 677
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574 626 57 648 613

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.11 -.07 -.08 -.09 -.06 -.01 -.03 -.07 -.00 .04 .07 .10 .08 -.03 -.11 -.16 -.06 -.06 -.16 -.02 .06 .05 .02 -.08 -.07 .22 417 419 438 388 404 402 411 411 430 388 394 394 394 392 405 489 293 391 317 377 405 438 291 391 317 317
       .23 .29 -.54 .00 -.56 -.17 -.01 .02 .15 -.04 .17 -.04 -.02 -.03 -.72 -.16 -.23 .52 -.08 .43 .00 .05 .04 .06 .51 .08 629 656 629 574 656 722 629 656 628 574 656 721 629 656 722 625 659 628 573 656 712 620 641 619 558 659
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                                                              .07 .16 .17 -.00 .02 .06 -.10 -.07 -.05 .01 .01 .01 -.12 -.09 .01 .05 .03 .02 .00 -.01 .03 .19 .20 .15 .09 .17 .05 .06 .07 .06 -.01 .04 -.09 -.12 -.07 .06 .02 .01 085 1856 605 627 277 577 631 636 605 611 7712 566 607 643 450 643 650 726 577 626 637 631 617 710 566 608 643 329 612 727 448 609 527 529 612 727 447 609 327
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657
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617 483 597 452 494
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548 482 350
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451 493 404 565
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385 380 581 609 608 561 608 561 560 609 608 560 609 608 560 649 592 609 640 540 540 540 540 540 540 540 540 540
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395 396 440 355 391 390 389
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446 446 409 409
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.00 -112 -16 -15 term. .04 19\$2 -07 -03 -05 term. .04 19\$2 -07 -03 -05 term. .04 19\$4 -111 .69 \text{\text{A}} term. .04 49-52



Aviation medicine	Aviation medicine
Medical statistics	Medical statistics
Aviators—Follow-up study	Aviators—Follow-up study
Osborne, R. K. W. R. Harlan, Jr., A Graybiel A LONGITUDINAL STUDY OF HEALTHY YOUNG MEN: CORRELATION COFFICIENTS. BuMed Project MR005.13-3001 Subtask 2, Report No. 7. Pensacola, Fla.: Naval School of Aviation Medicine, 15 July. A longitudinal study of a group of healthy young men followed over an 18-year period is described. The relationships among data from three examinations of this group are presented in the form of correlation coefficients. A correlation matrix of 106 continuous variables is recorded as a reference for other investigators. Pertinent statistical considerations are outlined and briefly discussed.	Osborne, R. K. W. R. Harlan, Jr., A Graybiel A LONGITUDINAL STUDY OF HEALTHY YOUNG MEN: CORRELATION COEFFICIENTS. BuMed Project MR005.13-3001 Subtask 2, Report No. 7. Pensacola, Fla.: Naval School of Aviation Medicine, 15 July. A longitudinal study of a group of healthy young men followed over an 18-year period is described. The relationships among data from three examinations of this group are presented in the form of correlation coefficients. A correlation matrix of 106 continuous variables is recorded as a reference for other investigators. Pertinent statistical considerations are outlined and briefly discussed.
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